CLAIMS

What is claimed is:

1. A rotary disk refiner for refining fibrous pulp in a liquid stock comprising:

a housing having a stock inlet;

a rotor within the housing that rotates about an axis of rotation during operation;

a refiner disk mounting surface within the housing that opposes the rotor;

a first refiner disk carried by the rotor, the first refiner disk comprised of a plurality of pairs of upraised bars that define grooves therebetween that collectively form a first refining surface;

a second refiner disk carried by the refiner disk mounting surface, the second refiner disk comprised of a plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a second refining surface, wherein the second refiner disk opposes and is spaced from the first refiner disk, and wherein a refining zone is defined between the opposed refining surfaces of the first and second refiner disks; and

a sensor disposed in the refining surface of one of the first and second refiner disks that is exposed to the refining zone and that senses a characteristic of conditions in the refining zone.

2. The rotary disk refiner of claim 1 further comprising a spacer disposed between the sensor and the refiner disk in which the sensor is disposed.

3. The rotary disk refiner of claim 2 wherein the sensor comprises a pressure sensor.

4. The rotary disk refiner of claim 2 wherein the spacer has a tubular shape and is comprised of a thermally insulating material that thermally insulates the sensor from the thermal mass of the refiner disk in which the sensor is disposed.

5. The rotary disk refiner of claim 4 wherein the spacer is comprised of a ceramic insulating material having a sidewall thickness of at least 1/32 of an inch (0.8 mm) to sufficiently thermally isolate the sensor from the thermal mass of the refiner disk in which the sensor is disposed to prevent the thermal mass of the refiner disk from interfering with sensing of the characteristic of conditions in the refining zone.

6. The rotary disk refiner of claim 5 wherein the sensor comprises a temperature sensor.

7. The rotary disk refiner of claim 2 wherein the sensor has a sensing element that is disposed between the spacer and the refining zone.

8. The rotary disk refiner of claim 7 wherein the spacer is disposed in a bore in the refining surface.

9. The rotary disk refiner of claim 8 further comprising two pairs of the sensors and spacers with one of the spacers carrying one of the sensors and disposed in a first bore in the refiner disk refining surface and the other of the spacers carrying the other of the sensors and disposed in a second bore in the refiner disk refining surface.

10. The rotary disk refiner of claim 8 further comprising at least three pairs of the sensors and spacers with a first one of the spacers carrying a first one of the sensors and disposed in a first bore in the refiner disk refining surface, a second one of the spacers carrying a second one of the sensors and disposed in a second bore in the refiner disk refining surface, and a third one of the spacers carrying a third one of the sensors and disposed in a third bore in the refiner disk refining surface, wherein the first bore, the second bore, and the third bore are radially spaced apart.

11. The rotary disk refiner of claim 10 wherein the first bore, the second bore and the third bore are disposed along a generally radially extending line.

12. The rotary disk refiner of claim 7 wherein the spacer is tubular and disposed in a bore in the refiner disk refining surface and the sensor comprises a sensor housing

that is partially telescopically received in the spacer.

13. The rotary disk refiner of claim 12 wherein the spacer is attached to the refiner disk by a first bond and the sensor housing is attached to the spacer by a second bond.

14. The rotary disk refiner of claim 12 wherein the sensor housing encloses the sensing element, the sensing element is attached to the sensor housing by a bond, and the sensor housing is in contact with the liquid stock during refining.

15. The rotary disk refiner of claim 7 wherein (a) each refiner groove has a bottom axial surface and each refiner bar has an axial outer refining surface that is located a height above the bottom surface of an adjacent refiner groove, and (b) the sensor has an outer tip that is disposed between the axial outer refining surface of an adjacent one of refiner bars and the bottom axial surface of an adjacent one of the refiner grooves.

16. The rotary disk refiner of claim 15 wherein the spacer carries the sensor and is at least partially embedded in one of the refiner bars.

17. The rotary disk refiner of claim 16 wherein the spacer is completely embedded in the one of the refiner bars.

18. The rotary disk refiner of claim 15 wherein the spacer carries the sensor and both the spacer and sensor are disposed in one of the refiner grooves.

19. The rotary disk refiner of claim 18 wherein the spacer and sensor form a dam in the one of the refiner grooves that obstructs the radial outward flow of stock in the one of the refiner grooves.

20. The rotary disk refiner of claim 1 wherein there are a plurality of the sensors that are spaced apart and each of the sensors is embedded in the refining surface of the refiner disk in which it is disposed.

21. The rotary disk refiner of claim 20 wherein each refiner groove has a bottom surface, each refiner bar has an axial outer surface, each of the sensors has a tip and the tip of each of the sensors is disposed flush with or below the axial outer surface of an adjacent one of the refiner bars.

22. The rotary disk refiner of claim 21 wherein the tip of each of the sensors is disposed between the axial outer surface of an adjacent one of the refiner bars and the bottom surface of an adjacent one of the refiner grooves.

23. The rotary disk refiner of claim 22 wherein the sensor comprises a sensor housing having the tip and a sensing element located inside the sensor housing that is disposed between the tip and the spacer.

24. The rotary disk refiner of claim 23 wherein the sensor housing contacts stock from the refining zone during operation of the rotary disk refiner.

25. The rotary disk refiner of claim 23 wherein (a) the spacer has an axial end disposed between the axial outer surface of the adjacent one of the refiner bars and the bottom surface of the adjacent one of the refiner grooves, (b) the sensing element has an axial end disposed between the axial outer surface of the adjacent one of the refiner bars and the bottom surface of the adjacent one of the refiner grooves, and (c) the axial end of the sensing element is disposed between the axial end of the spacer and the axial outer surface of the adjacent one of the refiner bars.

26. The rotary disk refiner of claim 1 wherein the first and second refiner disks are each comprised of a plurality of disk segments, wherein the sensor is disposed in one of the segments of the refiner disk in which the sensor is disposed, and further comprising a tubular spacer disposed in a bore in the refining surface of the disk segment in which the sensor is disposed, and wherein the spacer telescopingly receives the sensor with part of the sensor protruding from the spacer.

27. The rotary disk refiner of claim 1 wherein (a) each refiner groove has a bottom axial surface and each refiner bar has an axial outer refining surface that is located a height above the bottom surface of an adjacent refiner groove; (b) the sensor has a tip that is disposed between the axial outer refining surface of an adjacent one of refiner bars and the bottom axial surface of an adjacent one of the refiner grooves, and (c) the tip of the sensor is disposed at least 0.050 inch (1.27 mm) below the axial outer surface of the adjacent refiner groove so that the tip of the sensor remains flush with or below the axial surface of the adjacent one of the refiner bars when the adjacent one of refiner bars wears as a result of refiner operation.

28. The rotary disk refiner of claim 27 wherein the sensor further comprises a spacer, a sensor housing that extends outwardly from the spacer, and a sensing element carried by the sensor housing, wherein the spacer is embedded in the refiner disk and disposed between the sensing element and the refiner disk.

29. A rotary disk refiner for refining fibrous pulp in a liquid stock comprising:

a housing having a stock inlet;

a rotor within the housing that rotates about an axis of rotation during operation;

a refiner disk mounting surface within the housing that opposes the rotor;

a first refiner disk carried by the rotor, the first refiner disk comprised of a

plurality of refiner disk segments that each have plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a first refining surface;

a second refiner disk carried by the refiner disk mounting surface, the second refiner disk comprised of a plurality of refiner disk segment that each have a plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a second refining surface, wherein the second refiner disk opposes and is spaced from the first refiner disk, and wherein a refining zone is defined between the opposed refining surfaces of the first and second refining disks, wherein an elongate pocket is in the refining surface of one of the refiner disk segments of one of the first and second refiner disks;

a plate disposed in the elongate pocket; and

a sensor and a spacer embedded in the plate with the sensor being carried by the spacer and spaced from bar by the spacer.

30. The rotary disk refiner of claim 29 wherein the sensor comprises a sensor housing that extends from the spacer and a sensing element carried by the sensor housing.

31. The rotary disk refiner of claim 30 wherein (a) the sensing element is a temperature sensing element, (b) the sensor housing and spacer completely encloses the

temperature sensing element and prevents stock in the refining zone from directly contacting the temperature sensing element, (c) the spacer comprises an insulating spacer that thermally insulates the temperature sensing element from the thermal mass of the refiner disk segment in which the plate is disposed, and (d) the sensor housing contacts the stock during refiner operation.

32. A rotary disk refiner for refining fibrous pulp in a liquid stock comprising:

a housing having a stock inlet;

a rotor within the housing that rotates about an axis of rotation during operation;

a refiner disk mounting surface within the housing that opposes the rotor;

a first refiner disk carried by the rotor, the first refiner disk comprised of a plurality of refiner disk segments that each have plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a first refining surface;

a second refiner disk carried by the refiner disk mounting surface, the second refiner disk comprised of a plurality of refiner disk segment that each have a plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a second refining surface, wherein the second refiner disk opposes and is spaced from the first refiner disk, and wherein a refining zone is defined between the opposed refining surfaces of the first and second refining disks; and

a sensor embedded in the refining surface of one of the refiner disk segments of

one of the first and second refining disks, the sensor being exposed to the refining zone such that the sensor comes into contact with stock during operation, and the sensor sensing a characteristic of conditions in the refining zone.

33. The rotary disk refiner of claim 32 wherein the sensor further comprises an insulating spacer embedded in the refining surface of the one of the refiner disk segments, a sensor housing extending outwardly from the insulating spacer, and a sensing element that is carried by the sensor housing.

34. The rotary disk refiner of claim 33 wherein (a) the sensing element comprises a temperature sensor, (b) the characteristic sensed is temperature in the refining zone adjacent the sensor, and (c) the housing and insulating spacer completely enclose the sensing element such that it does not come into contact with the stock during disk refiner operation.

35. A rotary disk refiner for refining fibrous pulp in a liquid stock comprising:

a housing having a stock inlet;

a rotor within the housing that rotates about an axis of rotation during operation;

a refiner disk mounting surface within the housing that opposes the rotor;

a first refiner disk carried by the rotor, the first refiner disk comprised of a plurality of refiner disk segments that each have plurality of pairs of upraised refiner

bars that define refiner grooves therebetween that collectively form a first refining surface;

a second refiner disk carried by the refiner disk mounting surface, the second refiner disk comprised of a plurality of refiner disk segment that each have a plurality of pairs of upraised refiner bars that define refiner grooves therebetween that collectively form a second refining surface, wherein the second refiner disk opposes and is spaced from the first refiner disk, and wherein a refining zone is defined between the opposed refining surfaces of the first and second refiner disks;

a thermally insulating spacer embedded in the refining surface of one of the refiner disk segments of one the first and second refining disks;

a sensor housing extending from the thermally insulating spacer;

a temperature-sensing element carried by the sensor housing;

wherein the sensor housing contacts stock during refiner operation and the thermally insulating spacer thermally insulates the sensing element from the thermal mass of the refiner disk segment in which the insulating spacer is embedded.

36. The rotary disk refiner of claim 35 wherein (a) the sensor housing is comprised of a thermally conductive material, (b) the temperature sensing element is disposed inside the sensor housing, and (c) the sensor housing and the thermally insulating spacer enclose the temperature sensing element.

37. A refiner disk for a rotary disk refiner comprising a refining surface comprised of a plurality of spaced apart and upraised refiner bars that define therebetween refiner grooves and a sensor disposed in the refining surface.

38. The refiner disk of claim 37 wherein the sensor is at least partially disposed in one of the refiner bars.

39. The refiner disk of claim 37 wherein the sensor is disposed in one of the refiner grooves.

40. The refiner disk of claim 37 wherein the refining surface surrounds the entire periphery of the sensor.

41. The refiner disk of claim 40 further comprising a spacer disposed between the refiner disk and the sensor.

42. The refiner disk of claim 41 wherein the spacer is disposed in a bore in the refining surface.

43. The refiner disk of claim 42 wherein the spacer is tubular and the sensor is partially telescopically received in the spacer.

44. The refiner disk of claim 43 wherein the sensor comprises a temperature sensor and the spacer comprises an insulating spacer.

45. The refiner disk of claim 37 wherein the sensor has a tip that does not extend above any of the refiner bars.

46. The refiner disk of claim 45 wherein the sensor is imbedded in the refining surface.

47. The refiner disk of claim 46 comprising a plurality of the sensors that are radially spaced apart and each carried by a spacer that is disposed between the refiner disk and the sensor.

48. A refiner disk segment for a rotary disk refiner comprising a refining surface comprised of a plurality of spaced apart and upraised refiner bars that define therebetween refiner grooves and a sensor disposed in the refining surface.

49. The refiner disk segment of claim 48 wherein the sensor is at least partially disposed in one of the refiner bars.

50. The refiner disk segment of claim 48 wherein the sensor is disposed in one of the refiner grooves.

51. The refiner disk of claim 48 wherein the refining surface surrounds the entire periphery of the sensor.

52. The refiner disk of claim 51 further comprising a spacer disposed between the refiner disk and the sensor.

53. The refiner disk of claim 51 wherein the spacer is disposed in a bore in the refining surface.

54. The refiner disk of claim 53 wherein the spacer is tubular and the sensor is partially telescopically received in the spacer.

55. The refiner disk of claim 54 wherein the sensor comprises a temperature sensor and the spacer comprises an insulating spacer.

56. The refiner disk of claim 48 wherein the sensor has a tip that does not extend above any of the refiner bars.

57. The refiner disk of claim 56 wherein the sensor is imbedded in the refining surface.

58. The refiner disk of claim 57 comprising a plurality of the sensors that are radially spaced apart and each carried by a spacer that is disposed between the refiner disk and the sensor.